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TGO/NOMAD Nadir observations during the 2018 global dust storm event

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Abstract

In this work we present an analysis of data acquired by the LNO channel of the *Nadir and Occultation for MArs Discovery* spectrometer (NOMAD, [1]), onboard the ExoMars *Trace Gas Orbiter* (TGO) spacecraft currently orbiting Mars. The data cover the period before-during and after the global dust storm event occurred in 2018. We have developed some spectral indexes to quantify the dust loading of the atmosphere and the CO_2/H_2O ices presence.

1. Introduction

The NOMAD (Nadir and Occultation measurements for Mars Discovery) spectrometer suite onboard the joint ESA-Roscosmos ExoMars Trace Gas Orbiter mission is mapping the composition and distribution of Mars' atmospheric trace species in unprecedented detail. The instrument is a combination of three channels, covering a spectral range from the UV to the IR, and can perform solar occultation, nadir and limb observations. NOMAD is an international collaboration led by Belgium, with major contributions from Italy, Spain and UK.

The NOMAD instrument is capable to observe with different pointing geometries taking advantage of three channels: UVIS, operating in the ultraviolet/visible range 0.2 – 0.65 µm, working both in nadir and solar occultation geometries; LNO, covering the infrared range 2.3 – 3.8 µm, working in nadir, limb and solar occultation geometries; SO, working in the range 2.3 – 4.3 µm and performing dedicated solar occultation measurements. Although NOMAD has been mainly conceived to study the trace gases in the atmosphere of the red planet, it can also provide valuable information regarding the properties of Martian dust and ices. Martian dust can affect the abundance and distribution of atmospheric trace gases [5], whose investigation is fundamental to understand the atmosphere past evolution and provides insights on the research of biotic activities on the planet. Recent studies focused on the 2018 global-scale dust event as observed from the suite of instruments onboard the TGO spacecraft [2] highlight the role of dust as driver for the trace gases evolution.

2. Observations

We used the NOMAD Nadir data to map the developing and evolution of the global dust storm and the presence of ices, between Ls=148-280°. In particular, we made use of selected spectral orders, 190 and 169, which allow to discriminate between dust and ices. Order 190 correspond to a wavelength λ=2.333 µm and order 169 to λ=2.625 µm. The former is on the radiance continuum, free from gaseous absorption hence, it is suitable to investigate dust properties. The latter falls on the shoulder of the 2.7-3 µm CO_2/H_2O ices absorption. The data have been selected limiting the solar zenith angle to SZA<=75°, avoiding the data with poor signal-noise ratio. Raw data have been calibrated in radiance units by using solar scans.

3. Method and results

To evaluate the dust and ices content, we have defined two spectral indexes. The first index, called Surface Index (SI) is defined as:

$$SI = \frac{L_{NOMAD}}{L_{Sun} \mathrm{x}\, A_M}$$

where L_{NOMAD} is the Mars's radiance as measured by NOMAD at the selected order and corrected for *cos(SZA)*, L_{Sun} is the solar radiance and A_M is the Mars albedo at the corresponding wavelength. The albedo has been derived from TES bolometric albedo and rescaled at wavelengths of interest by using the

OMEGA data set. Values of SI~1 indicate a relatively low atmospheric dust loading and lack of ices, both in the atmosphere and on the surface. SI>1 indicate presence of atmospheric effects due either to dust/clouds or to condensation of ices on the surface, while SI<1 indicate presence of ices. The other index is for ices detection and is defined as:

$$Ices\ Index = \frac{SI_{Order\ 190}}{SI_{Order\ 169}}$$

Both spectral indexes have been organized as Latitude-Solar longitude maps, by performing zonal averages on all observed longitudes. Figure 1 shows the map of SI for order 190. The period before Ls=185° shows an atmosphere relatively clean (SI<1.8), especially at latitudes between 30-60° S. Starting of global dust storm is clearly seen at Ls~190° with SI reaching 4.5 mostly at equatorial-meridional latitudes. The atmosphere dust loading remains high (SI>2.5), at least until the last reported Ls (280°). At latitudes < 60° S the sublimation of the seasonal polar cap is also visible. Here, the SI has generally values ~2.5, reaching a peak > 4 at Ls=220-240°. Figure 2 shows the SI for order 169. It is quite like Figure 1, except for latitudes < 60° S where now the presence of ices is depicted by SI<1.

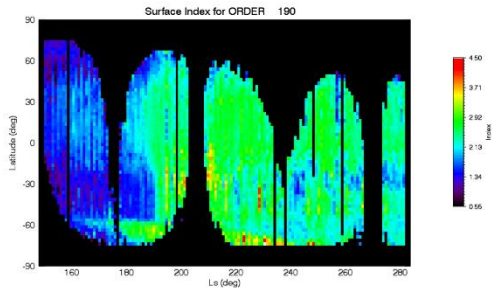

Figure 1. Map of Surface Index for order 190, showing the onset of global dust storm.

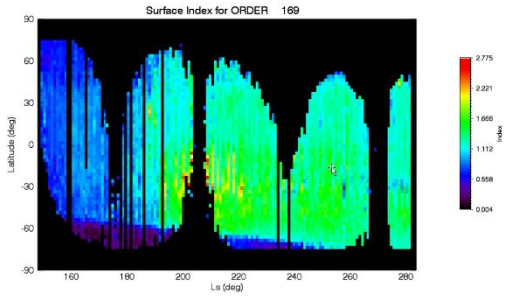

Figure 2. Map of Surface Index for order 169, showing the onset of global dust storm and sublimation of CO2 cap.

Figure 3 shows the map of ices index. The behaviour agrees quite well with GCM predictions, except at Ls~220°, where a lower CO2 content is observed.

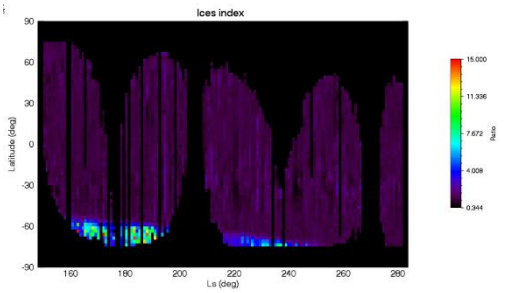

Figure 3. Map of Ices Index, showing the CO2 sublimation of meridional seasonal cap.

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